ANNEX 3

(of Appendix 30A (S30A))

(MOD)

Technical Data Used in Establishing the Provisions and Associated Plans and Which Should be Used for their Application[1]

1. DEFINITIONS

(MOD)

1.1 Feeder link

The term feeder link, as defined in No. **S1.115** of the Radio Regulations, is further qualified to indicate a fixed-satellite service link in the frequency band 17.3 - 17.8 GHz in the Region 2 broadcasting-satellite service Plan and in the frequency bands 14.5 - 14.8 GHz for countries outside Europe, and 17.3 - 18.1 GHz in the Regions 1 and 3 Plan from any earth station within the feeder-link service area to the associated space station in the broadcasting-satellite service.

NOC

1.2 Feeder-link beam area

The area delineated by the intersection of the half-power beam of the satellite receiving antenna with the surface of the Earth.

NOC

1.3 Feeder-link service area

The area on the surface of the Earth within the feeder-link beam area within which the administration responsible for the service has the right to locate transmitting earth stations for the purpose of providing feeder links to broadcasting-satellite space stations.

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[1] In revising this Annex at WRC-97, no changes were made to the technical data applicable to the Region 2 Plan. However, for all three Regions it should be noted that some of the parameters of networks proposed as modifications to the Plans may differ from the technical data presented herein.

NOC

1.4 Nominal orbital position

The longitude of a position in the geostationary-satellite orbit associated with a frequency assignment to a space station in a space radiocommunication service. The position is given in degrees from the Greenwich meridian.

(MOD)

1.5 Adjacent channel

The RF channel in the broadcasting-satellite service frequency Plan, or in the associated feeder-link frequency Plan, which is situated immediately higher or lower in frequency with respect to the reference channel.

(MOD)

1.6 Second adjacent channel

The RF channel in the broadcasting-satellite service frequency Plan, or in the associated feeder-link frequency Plan, which is situated immediately beyond either of the adjacent channels, with respect to the reference channel.

(MOD)

1.7 Feeder-link equivalent protection margin for Regions 1 and 3[1]

The feeder-link equivalent protection margin (M_u) is given by the formula:

$$M_u = -10 \log \left(10^{-M_1/10} + 10^{-M_2/10} + 10^{-M_3/10}\right) \text{ dB}$$

where:

M_1 is the value in dB of the protection margin for the same channel, i.e.:

$$M_1 = \left[\frac{\text{wanted power}}{\text{sum of the co-channel interfering powers}}\right](\text{dB}) - \begin{array}{l}\text{co-channel}\\ \text{protection ratio (dB)}\end{array}$$

[1] This quantity is used in the alternative formula for the overall equivalent protection margin given in Section 1.12 below. However, in certain cases (e.g. when the channel spacing and/or bandwidth are different from the values given in Sections 3.5 and 3.8 of Annex 5 to Appendix 30 (S30)), equivalent protection margins for the second adjacent channels may be used. Appropriate protection masks included in ITU-R Recommendations should be used if available. Until a relevant ITU-R Recommendation is incorporated in this Annex by reference, the Bureau will use the worst-case approach as adopted by the Radio Regulations Board.

M_2 and M_3 are the values in dB of the protection margin for the upper and lower adjacent channels respectively, i.e.:

$$M_2 = \left[\frac{\text{wanted power}}{\begin{array}{c}\text{sum of the upper adjacent}\\ \text{channel interfering powers}\end{array}}\right](\text{dB}) - \begin{array}{l}\text{adjacent channel}\\ \text{protection ratio (dB)}\end{array}$$

$$M_3 = \left[\frac{\text{wanted power}}{\begin{array}{c}\text{sum of the lower adjacent}\\ \text{channel interfering powers}\end{array}}\right](\text{dB}) - \begin{array}{l}\text{adjacent channel}\\ \text{protection ratio (dB)}\end{array}$$

All powers are evaluated at the receiver input. All protection ratios are given in Section 3.3 of this Annex.

(MOD)

1.8 Overall carrier-to-interference ratio

The overall carrier-to-interference ratio is the ratio of the wanted carrier power to the sum of all interfering RF powers in a given channel including both feeder links and down-links. The overall carrier-to-interference ratio due to interference from the given channel is calculated as the reciprocal of the sum of the reciprocals of the feeder-link carrier-to-interference ratio and the down-link carrier-to-interference ratio referred to the satellite receiver input and earth station receiver input, respectively[1].

(MOD)

1.9 Overall co-channel protection margin

The overall co-channel protection margin in a given channel is the difference in dB between the overall co-channel carrier-to-interference ratio and the co-channel protection ratio.

(MOD)

[1] In Region 2 there are a total of five overall carrier-to-interference ratios used in the analysis of the Plan, namely, co-channel, upper and lower adjacent channels and upper and lower second adjacent channels. In Regions 1 and 3, three ratios are used, namely, co-channel and upper and lower adjacent channels.

(MOD)

1.10 Overall adjacent channel protection margin

The overall adjacent channel protection margin is the difference, in dB, between the overall adjacent channel carrier-to-interference ratio and the adjacent channel protection ratio.

(MOD)

1.11 Overall second adjacent channel protection margin

The overall second adjacent channel protection margin is the difference in dB between the overall second adjacent channel carrier-to-interference ratio and the second adjacent channel protection ratio.

(MOD)

1.12 Overall equivalent protection margin

The overall equivalent protection margin M is given in dB by the expression[1]:

$$M = -10 \log \left(\sum_{i=1}^{n} 10^{(-M_i/10)} \right) \quad \text{(dB)}$$

where:

n		is generally equal to 3 for Regions 1 and 3, n is equal to 5 for Region 2;
M_1	=	overall co-channel protection margin, in dB (as defined in Section 1.9);
M_2, M_3	=	overall adjacent channel protection margins for the upper and lower adjacent channels respectively, in dB (as defined in Section 1.10);
M_4, M_5[2]	=	overall second adjacent channel protection margins for the upper and lower second adjacent channels respectively, in dB (as defined in Section 1.11).

[1] This formula is also used to calculate the overall equivalent protection margin of the assignments notified, which are in conformity with this Appendix, brought into use, and for which the date of bringing into use has been confirmed to the Bureau before 27 October 1997.

[2] M_4 and M_5 are applicable only for Region 2. However, in certain cases (e.g. when the channel spacing and/or bandwidth are different from the values given in Sections 3.5 and 3.8 of Annex 5 to Appendix 30 (S30)), these margins may also be used for Regions 1 and 3. Appropriate protection masks included in ITU-R Recommendations should be used if available. Until a relevant ITU-R Recommendation is incorporated in this Annex by reference, the Bureau will use the worst-case approach as adopted by the Radio Regulations Board.

The adjective "equivalent" indicates that the protection margins for all interference sources from the adjacent and second adjacent as well as co-channel interference sources have been included.

The following alternative formula for overall equivalent protection margin was used at WARC ORB-88 in developing the original feeder-link Plan for Regions 1 and 3. It may be used as a tool to assess the relative contributions of the feeder link and downlink to the overall equivalent protection margin defined above .

$$M = -10 \log \left(10^{-(M_u + R_{cu})/10} + 10^{-(M_d + R_{cd})/10} \right) - R_{co}$$

where:

M_u = equivalent protection margin for the feeder link (as defined in Section 1.7 of this Annex);

M_d = equivalent protection margin for the down-link (as defined in Section 3.4, Annex 5 to Appendix **30 (S30)**);

R_{cu} = co-channel feeder-link protection ratio;

R_{cd} = co-channel down-link protection ratio;

R_{co} = co-channel overall protection ratio.

The values of the protection ratios used for the 1988 feeder-link Plan were as follows:

R_{cu} = 40 dB

R_{cd} = 31 dB

R_{co} = 30 dB

The adjective "equivalent" indicates that the protection margins for all interference sources from the adjacent channels as well as co-channel interference sources have been included.

The corresponding values for analysing the 1997 feeder-link Plan are:

R_{cu} = 30 dB

R_{cd} = 24 dB

R_{co} = 23 dB

However, the latter values are restricted to the case of channels having the standard channel spacing and necessary bandwidth given in Section 3.5 and 3.8, respectively, of Annex 5 to Appendix 30.

2. RADIO PROPAGATION FACTORS

The propagation loss on an Earth-space path is equal to the free-space path loss plus the atmospheric absorption loss plus the rain attenuation exceeded for 1% of the worst month in Region 2. In Regions 1 and 3, the atmospheric absorption loss is not included.

(MOD)

2.1 Atmospheric absorption

For Region 2 (see Figure 2)

The loss due to atmospheric absorption (i.e. clear-sky attenuation) is given by:

$$A_a = \frac{92.20}{\cos\theta}\left(0.020F_o + 0.008\,\rho F_w\right) \quad \text{(dB)} \qquad \text{for } \theta < 5°$$

where:

$$F_o = \left\{24.88\tan\theta + 0.339\sqrt{1416.77\tan^2\theta + 5.51}\right\}^{-1}$$

$$F_w = \left\{40.01\tan\theta + 0.339\sqrt{3663.79\tan^2\theta + 5.51}\right\}^{-1}$$

and:

$$A_a = \frac{0.0478 + 0.0118\,\rho}{\sin\theta} \quad \text{(dB)} \qquad \text{for } \theta \geq 5°$$

where:

θ = the elevation angle (degrees),

ρ = the surface water vapour concentration, g/m^3, with

ρ = 10 g/m^3 for rain-climatic zones A to K and

ρ = 20 g/m^3 for rain-climatic zones M to P

For Regions 1 and 3 (see Figures 1 and 3 taken from Recommendation ITU-R P.837-1)

In the Regions 1 and 3 feeder-link Plan, the atmospheric absorption loss is not included for the calculation of margins.

(MOD)

2.2 Rain attenuation

The propagation model for feeder links using circularly polarized signals is based on the value of rain attenuation for 1% of the worst month.

Figures 1, 2 and 3 give the rain climatic zones for Regions 1, 2 and 3.

Figure 4 presents a plot of rain attenuation of circularly polarized signals exceeded for 1% of the worst month at 17.5 GHz as a function of earth station latitude and elevation angle for each of the rain climatic zones in Region 2.

For calculation, the following data are needed:

$R_{0.01}$: point rainfall rate for the location exceeded for 0.01% of an average year (mm/h)

h_o: the height above mean sea level of the earth station (km)

θ: the elevation angle (degrees)

f: frequency (GHz)

ζ: latitude of earth station (degrees).

Mean frequencies will be used for calculations for the frequency bands, i.e. 17.7 GHz and 14.65 GHz for Regions 1 and 3, 17.5 GHz for Region 2.

The calculation procedure used for the Region 2 feeder-link Plan and for the original 1988 Regions 1 and 3 feeder-link Plan consists of the following seven steps:

Step 1: The mean zero-degree isotherm height h_F is:

$$h_F = 5.1 - 2.15 \log \left[1 + 10^{\frac{(|\zeta| - 27)}{25}} \right] \quad \text{(km)}$$

Step 2: The rain height h_R is:

$$h_R = C \cdot h_F \quad \text{(km)}$$

where: $C = 0.6$ for $0° \leq |\zeta| < 20°$

$C = 0.6 + 0.02\,(|\zeta| - 20)$ for $20° \leq |\zeta| < 40°$

$C = 1$ for $|\zeta| \geq 40°$

Step 3: The slant-path length, L_s, below the rain height is:

$$L_s = \frac{2(h_R - h_o)}{\left[\sin^2 \theta + 2 \frac{(h_R - h_o)}{R_e} \right]^{1/2} + \sin \theta} \quad \text{(km)}$$

where:

R_e is the effective radius of the Earth (8500 km)

Step 4: The horizontal projection, L_G, of the slant-path is:

$$L_G = L_s \cos \theta \quad \text{(km)}$$

Step 5: The rain path reduction factor $r_{0.01}$, for 0.01% of the time is:

$$r_{0.01} = \frac{90}{90 + 4L_G}$$

Step 6: The specific attenuation γ_R is determined from:

$$\gamma_R = k\,(R_{0.01})^{\alpha} \quad \text{(dB/km)}$$

where:

$R_{0.01}$ is given in Table 5 for each rain climatic zone. The frequency dependent coefficients k and α are given in Table 6 and the rain climatic zones are given in Figures 1, 2 and 3 for Regions 1, 2 and 3.

(MOD)

TABLE 5

Rainfall intensity (R) for the rain climatic zones (exceeded for 0.01% of an average year)

Rain climatic zone	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q
Rainfall intensity (mm/h)	8	12	15	19	22	28	30	32	35	42	60	63	95	145	115

TABLE 6

Frequency dependent coefficients

Frequency (GHz)	k	α	
14.65	0.0327	1.149	For Regions 1 and 3
17.5	0.0521	1.114	For Region 2
17.7	0.0531	1.110	For Regions 1 and 3

Step 7: The attenuation exceeded for 1% of the worst month is:

$$A_{1\%} = 0.223\ \gamma_R\ L_s\ r_{0.01}\ \text{(dB) for Regions 1 and 3}$$

$$A_{1\%} = 0.21\ \gamma_R\ L_s\ r_{0.01}\ \text{(dB) for Region 2}$$

For calculation of the permissible increase in e.i.r.p. to overcome rain fading (power control, see 3.11.1 of this Annex) in the revised Regions 1 and 3 Plan (WRC-97), the same calculation procedure is used with the following changes to conform to Recommendation ITU-R P.618-5.

To calculate the rain height h_R *steps 1 and 2* are replaced by:

$$h_R\ (km) = \begin{cases} 5 - 0.075(\zeta - 23) & \textit{for} \quad \zeta > 23° & \textit{Northern Hemisphere} \\ 5 & \textit{for} \quad 0° \le \zeta \le 23° & \textit{Northern Hemisphere} \\ 5 & \textit{for} \quad 0° \ge \zeta \ge -21° & \textit{Southern Hemisphere} \\ 5 + 0.1(\xi + 21) & \textit{for} \quad -71° \le \zeta < -21° & \textit{Southern Hemisphere} \\ 0 & \textit{for} \quad \zeta < -71° & \textit{Southern Hemisphere} \end{cases}$$

Steps 3 and 4 remain the same. However, to calculate the rain path reduction factor $r_{0.01}$, for 0.01% of the time, the equation of Step 5 is replaced by:

$$r_{0.01} = \frac{1}{1 + L_G/L_0}$$

where:

$L_o = 35 \exp(-0.015\ R_{o.o1})$

and $R_{o.o1}$ is given in Table 5 for each rain climatic zone.

Step 6 remains the same except the frequency dependant coefficients k and α shall be obtained from Recommendation ITU-R P.838.

Step 7 should be replaced as follows:

$$\frac{A_p}{A_{0.01}} = 0.12\, p^{-(0.546\ +\ 0.043 \log p)}$$

where:

$$p(\%) = 0.30\, p_w(\%)^{1.15} \qquad \text{(Rec. ITU-R P.841)}$$

p is the average annual time percentage of excess corresponding to desired worst-month time percentage of excess p_w.

NOC

2.3 Rain attenuation limit

In the analysis of the Plan for Region 2, a maximum rain attenuation on the feeder link of 13 dB was considered assuming that other means would be used at the implementation stage to compensate for larger rain attenuation on the feeder link.

In the analysis of the Regions 1 and 3 Plan, no rain attenuation is included in the margins.

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2.4 Depolarization

Rain and ice can cause depolarization of radio frequency signals. The level of the co-polar component relative to the depolarized component is given by the cross-polarization discrimination (XPD) ratio. For the feeder link, the XPD ratio, in dB, not exceeded for 1% of the worst month, is given by:

$$XPD = 30 \log f - 40 \log (\cos \theta) - V \log A_p \text{ (dB) for } 5° \leq \theta \leq 60°$$

where: $V = 20$ for 14.5 - 14.8 GHz

and $V = 23$ for 17.3 - 18.1 GHz

where: A_p: co-polar rain attenuation exceeded for 1% of the worst month

f: frequency (GHz)

θ: elevation angle (degrees)

To calculate the depolarization value to be used for power control in the Regions 1 and 3 Plan, the following algorithm, which was obtained from ITU-R Recommendation P.618-5, shall be used:

To calculate long-term statistics of depolarization from rain attenuation statistics the following parameters are needed:

A_p: rain attenuation (dB) exceeded for the required percentage of time, p, for the path in question, commonly called co-polar attenuation, CPA

τ: tilt angle of the linearly polarized electric field vector with respect to the horizontal (for circular polarization use $\tau = 45°$)

f: frequency (GHz)

θ: path elevation angle (degrees).

The method described below to calculate cross-polarization discrimination (XPD) statistics from rain attenuation statistics for the same path is valid for 8 GHz $\leq f \leq$ 35 GHz and $\theta \leq 60°$.

Step 1: Calculate the frequency-dependent term:

$$C_f = 30 \log f \quad \text{for } 8 \leq f \leq 35 \text{ GHz}$$

Step 2: Calculate the rain attenuation dependent term:

$$C_A = V(f) \log A_p$$

where:

$$V(f) = 12.8 f^{0.19} \quad \text{for } 8 \leq f \leq 20 \text{ GHz}$$

$$V(f) = 22.6 \quad \text{for } 20 < f \leq 35 \text{ GHz}$$

Step 3: Calculate the polarization improvement factor:

$$C_\tau = -10 \log \left[1 - 0.484 \left(1 + \cos 4\tau \right) \right]$$

The improvement factor $C_\tau = 0$ for $\tau = 45°$ and reaches a maximum value of 15 dB for $\tau = 0°$ or $90°$.

Step 4: Calculate the elevation angle-dependent term:

$$C_\theta = -40 \log (\cos \theta) \quad \text{for } \theta \leq 60°$$

Step 5: Calculate the canting angle dependent term:

$$C_\sigma = 0.0052\, \sigma^2$$

σ is the effective standard deviation of the raindrop canting angle distribution, expressed in degrees; σ takes the value 0°, 5°, 10° and 15° for 1%, 0.1%, 0.01% and 0.001% of the time, respectively.

Step 6: Calculate rain XPD not exceeded for *p*% of the time:

$$XPD_{rain} = C_f - C_A + C_\tau + C_\theta + C_\sigma \quad \text{dB}$$

Step 7: Calculate the ice crystal dependent term:

$$C_{ice} = XPD_{rain} \times (0.3 + 0.1 \log p)/2 \quad \text{dB}$$

Step 8: Calculate the XPD not exceeded for *p*% of the time, including the effects of ice:

$$XPD_p = XPD_{rain} - C_{ice} \quad \text{dB}$$

For values of θ greater than 60°, use $\theta = 60°$ in the above equations.

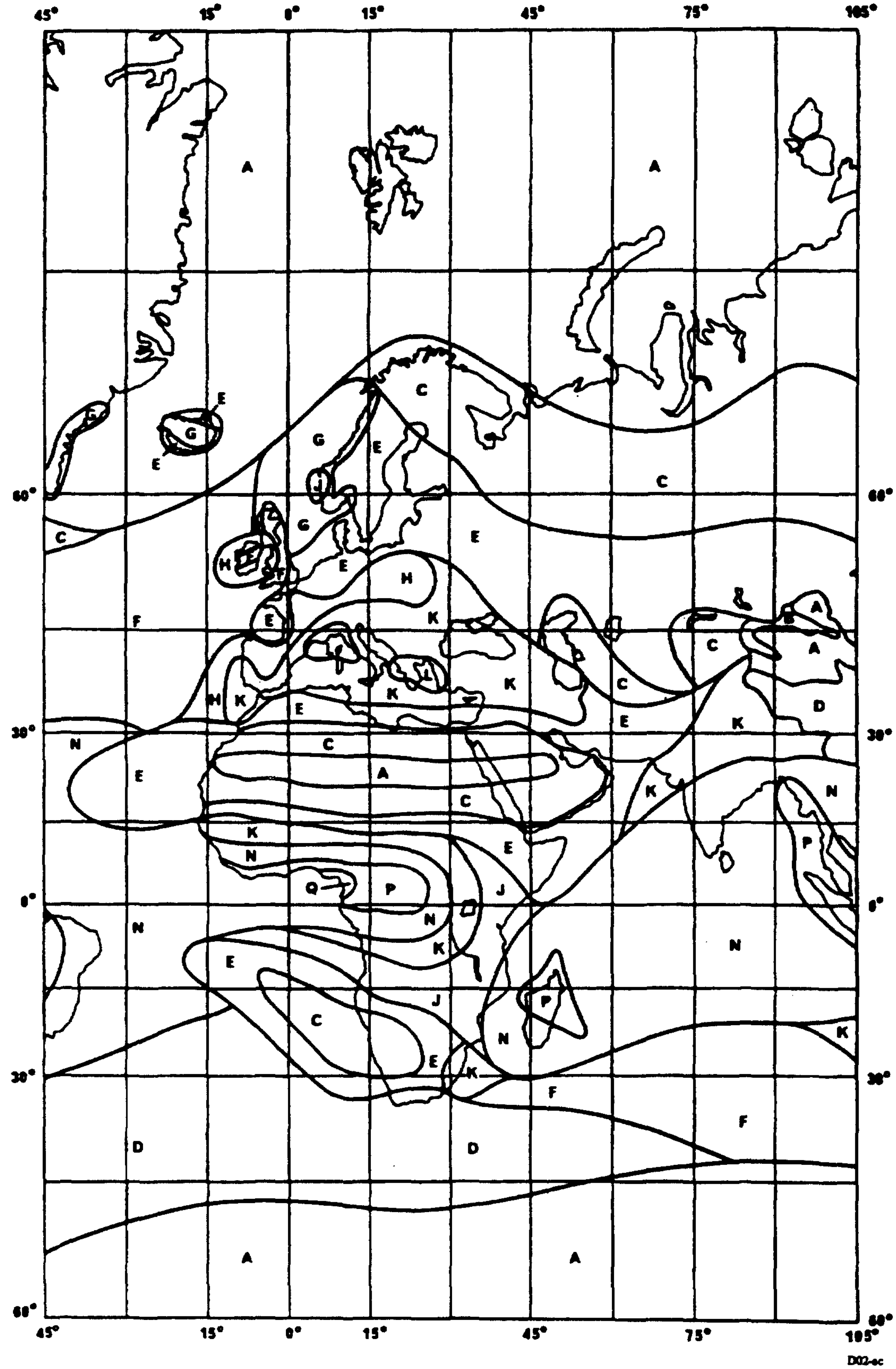

FIGURE 1

Rain climatic zones for Regions 1 and 3 between longitudes 45° W and 105° E

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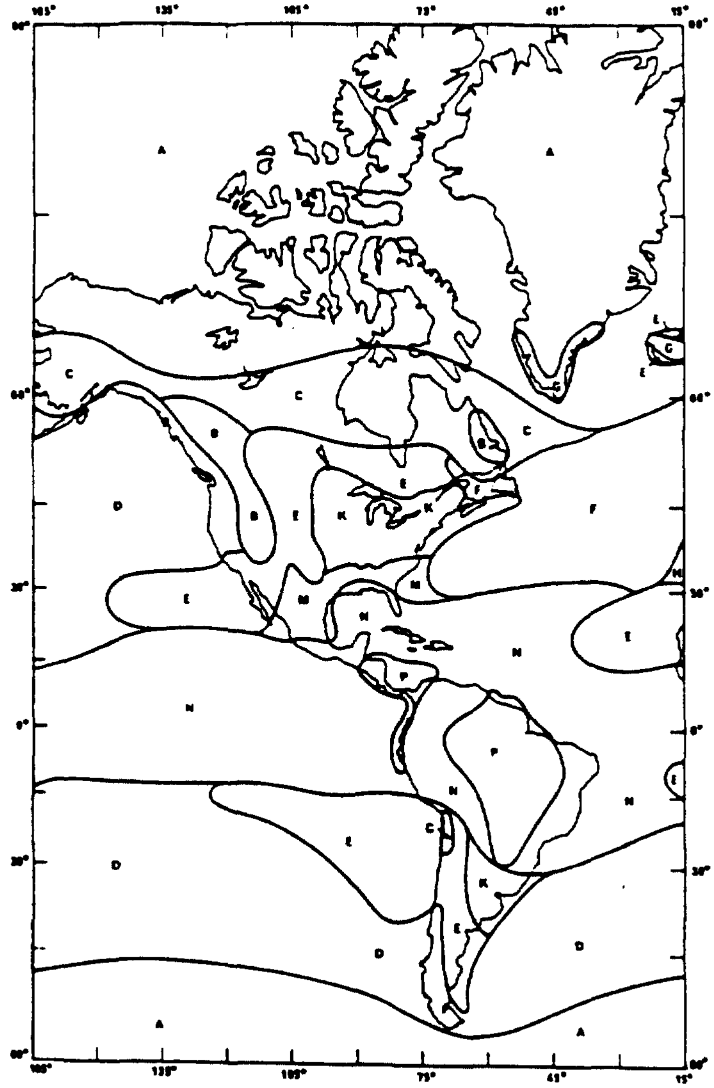


FIGURE 2

Rain climatic zones (Regions 2)

(MOD)

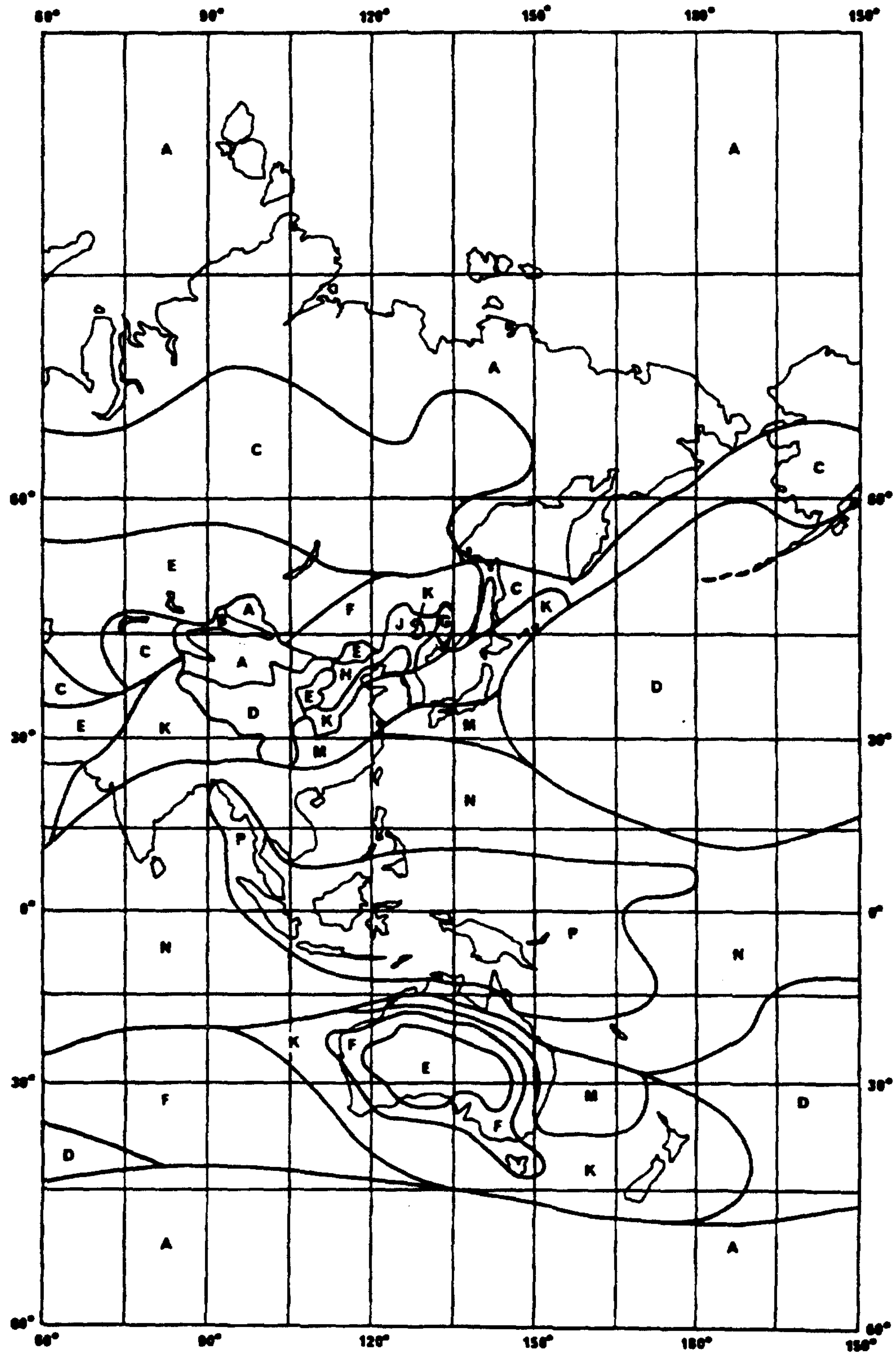
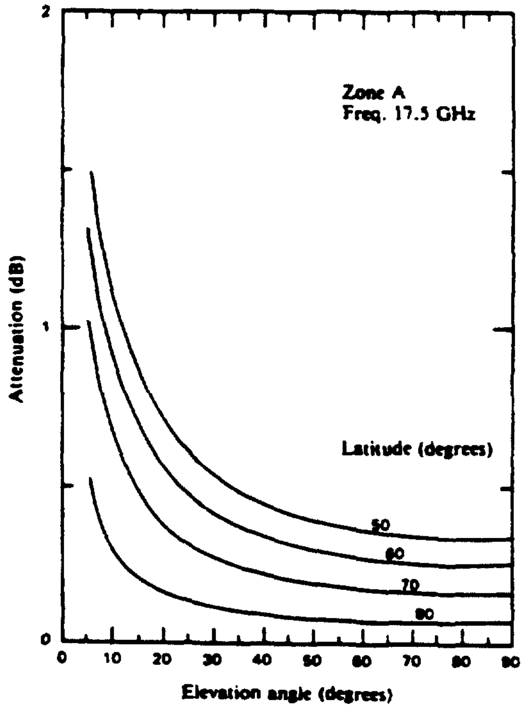
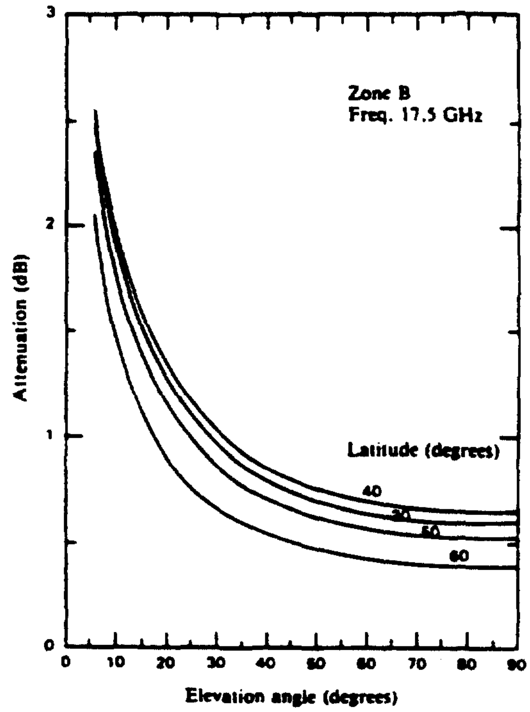


FIGURE 3

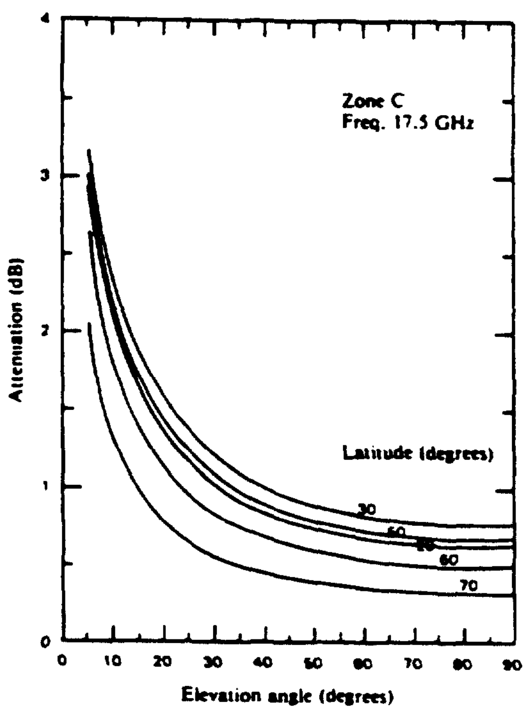
Rain climatic zones for Regions 1 and 3 between longitudes 60° E and 150° W



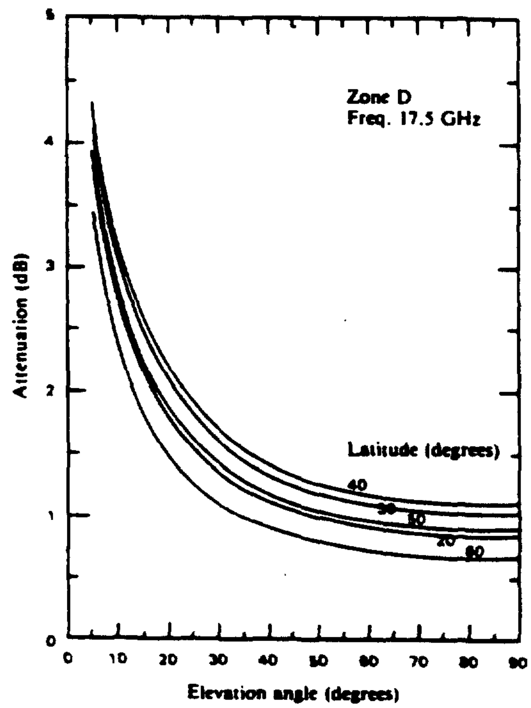
a) Rain climatic zone A



b) Rain climatic zone B



c) Rain climatic zone C

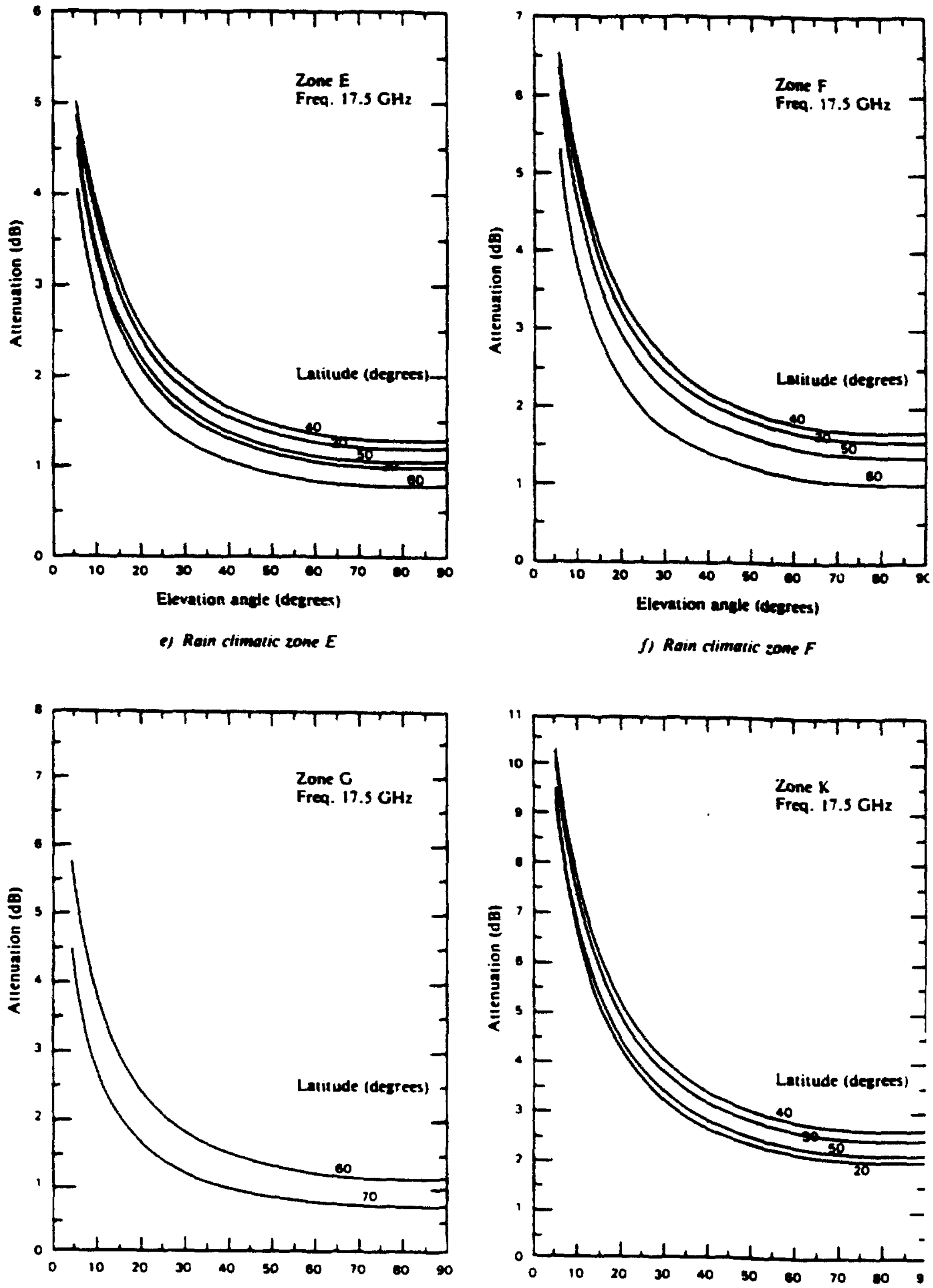


d) Rain climatic zone D

FIGURE 4

Rain attenuation values exceeded for 1% of the worst month (sea level) for Region 2 rain climatic zones

d04_04-sc



e) Rain climatic zone E

f) Rain climatic zone F

g) Rain climatic zone G

h) Rain climatic zone K

FIGURE 4 (cont.)

Rain attenuation values exceeded for 1% of the worst month (sea level) for Region 2 rain climatic zones

d04_05-ec

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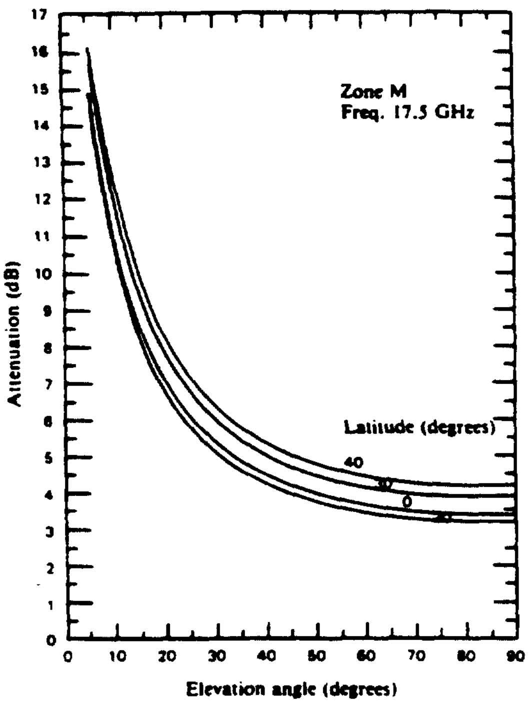
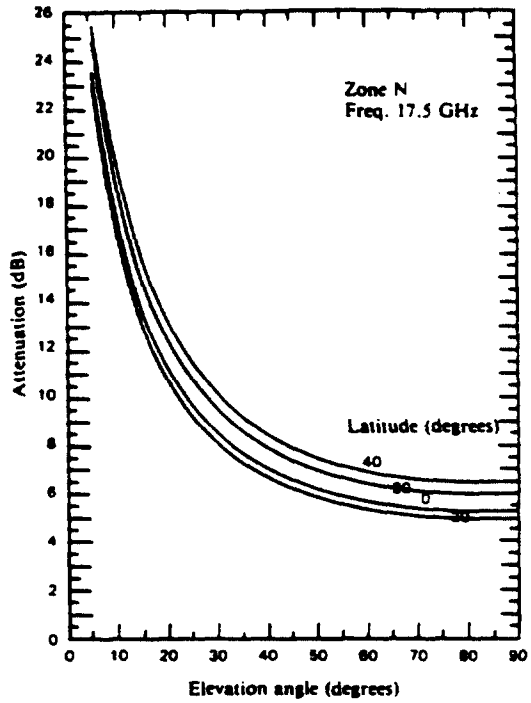
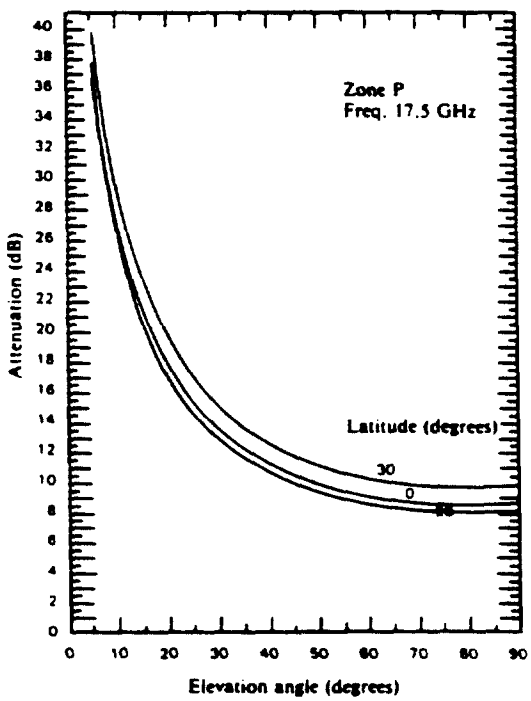


i) Rain climatic zone M



j) Rain climatic zone N



k) Rain climatic zone P

FIGURE 4 *(end)*

Rain attenuation values exceeded for 1% of the worst month (sea level)
for Region 2 rain climatic zones

d04_08-sc

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2.5 Procedure for calculating the carrier-to-interference ratio at a space station receiver input

In Region 2, the calculation of the feeder-link carrier-to-interference ratio (exceeded for 99% of the worst month) at a space station receiver input used to obtain the overall equivalent protection margin at a test point assumes a rain attenuation value not exceeded for 99% of the worst month on the wanted feeder-link path. For the interfering feeder-link signal path, clear sky propagation (i.e. including atmospheric absorption only) is assumed.

In Regions 1 and 3, the calculation of the feeder-link carrier-to- interference ratio at a space station receiver input used to obtain the feeder-link equivalent protection margin at a test point assumes free space conditions on the wanted feeder-link path and on the interfering feeder-link path.

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3. BASIC TECHNICAL CHARACTERISTICS FOR REGIONS 1 AND 3

(MOD)

3.1 Translation frequency and guard bands

a) 17 GHz feeder links

The feeder-link Plan generally uses a frequency translation of 5.6 GHz between the 17 GHz feeder-link channels and the 12 GHz down-link channels. Other values of the translation frequency may be used, provided that the corresponding channels have been assigned to the space station of the administration concerned.

With the value of frequency translation between the feeder-link frequency band (17.3 - 18.1 GHz in Regions 1 and 3) and the down-link frequency band (11.7 - 12.5 GHz in Region 1 and 11.7 - 12.2 GHz in Region 3), the guardbands specified in Section 3.9 of Annex 5 to Appendix 30 (S30) for the downlink Plan result in corresponding guardbands bandwidths of 11 MHz at the upper and 14 MHz at the lower feeder-link band edges. These feeder-link guardbands may be used for transmissions in the space operation service.

b) 14 GHz feeder links

As the maximum available bandwidth for the feeder-link band 14.5 - 14.8 GHz is only 300 MHz divided into fourteen 27 MHz channels against 800 MHz (40 channels) and 500 MHz (24 channels) in the down-link Plan for Regions 1 and 3 respectively, several translation frequencies must be considered to allow any channel in the Plan to be used. Consequently, a particular feeder-link channel has been assigned to several BSS Plan channels simultaneously.

Generally, the translation frequencies from the feeder-link channels are:

2797.82 MHz to down-link BSS channels 1 to 14

2529.30 MHz to down-link BSS channels 15 to 28

2260.78 MHz to down-link BSS channels 29 to 40

The guardband bandwidths are 11.80 MHz at the lower band edge and 11.86 MHz at the upper band edge.

c) *Frequency translation rules*

Specific rules for selecting appropriate frequency translations are given in Sections 6.2.1.2.2 and 6.2.1.3.3 (pages 95 and 96) of the WARC ORB-85 Report to WARC ORB-88. These rules permit the derivation of simple-to-use tables that define the channel translations that were avoided in revising the Regions 1 and 3 feeder-link Plan for both the 14 GHz and 17 GHz bands (see Tables 7 and 8).

(ADD)

TABLE 7

14.5 - 14.8 GHz/11.7 - 12.5 GHz channel translations that should be avoided as far as possible according to WARC ORB-85 frequency translation rules

14 GHz uplink channel number	Downlink channel numbers to be avoided as far as possible				
1	7	8	9	19	20
2	8	9	10	20	21
3	9	10	11	21	22
4	10	11	12	22	23
5	11	12	13	23	24
6	12	13	14	24	25
7	13	14	15	25	26
8	14	15	16	26	27
9	15	16	17	27	28
10	16	17	18	28	29
11	17	18	19	29	30
12	18	19	20	30	31
13	19	20	21	31	32
14	20	21	22	32	33

(ADD)

TABLE 8

17.3 - 18.1 GHz/11.7 - 12.5 GHz channel translations that should be avoided according to WARC ORB-85 frequency translation rules

17 GHz uplink channel number	Downlink channel numbers to be avoided (as far as possible)																													
1			10	11	12	13	14	15	16	17	18	19	20	21	22															
2			11	12	13	14	15	16	17	18	19	20	21	22	23															
3			12	13	14	15	16	17	18	19	20	21	22	23	24															
4			13	14	15	16	17	18	19	20	21	22	23	24	25															
5			14	15	16	17	18	19	20	21	22	23	24	25	26															
6			15	16	17	18	19	20	21	22	23	24	25	26	27															
7			16	17	18	19	20	21	22	23	24	25	26	27	28															
8			17	18	19	20	21	22	23	24	25	26	27	28	29															
9			18	19	20	21	22	23	24	25	26	27	28	29	30															
10	1			19	20	21	22	23	24	25	26	27	28	29	30	31														
11	1	2			20	21	22	23	24	25	26	27	28	29	30	31	32													
12	1	2	3			21	22	23	24	25	26	27	28	29	30	31	32	33												
13	1	2	3	4			22	23	24	25	26	27	28	29	30	31	32	33	34											
14	1	2	3	4	5			23	24	25	26	27	28	29	30	31	32	33	34	35										
15	1	2	3	4	5	6			24	25	26	27	28	29	30	31	32	33	34	35	36									
16	1	2	3	4	5	6	7			25	26	27	28	29	30	31	32	33	34	35	36	37								
17	1	2	3	4	5	6	7	8			26	27	28	29	30	31	32	33	34	35	36	37	38							
18	1	2	3	4	5	6	7	8	9			27	28	29	30	31	32	33	34	35	36	37	38	39						
19	1	2	3	4	5	6	7	8	9	10			28	29	30	31	32	33	34	35	36	37	38	39	40					
20	1	2	3	4	5	6	7	8	9	10	11			29	30	31	32	33	34	35	36	37	38	39	40					
21	1	2	3	4	5	6	7	8	9	10	11	12			30	31	32	33	34	35	36	37	38	39	40					
22	1	2	3	4	5	6	7	8	9	10	11	12	13			31	32	33	34	35	36	37	38	39	40					
23	1	2	3	4	5	6	7	8	9	10	11	12	13	14			32	33	34	35	36	37	38	39	40					
24		2	3	4	5	6	7	8	9	10	11	12	13	14	15			33	34	35	36	37	38	39	40					
25			3	4	5	6	7	8	9	10	11	12	13	14	15	16			34	35	36	37	38	39	40					
26				4	5	6	7	8	9	10	11	12	13	14	15	16	17			35	36	37	38	39	40					
27					5	6	7	8	9	10	11	12	13	14	15	16	17	18			36	37	38	39	40					
28						6	7	8	9	10	11	12	13	14	15	16	17	18	19			37	38	39	40					
29							7	8	9	10	11	12	13	14	15	16	17	18	19	20			38	39	40					
30								8	9	10	11	12	13	14	15	16	17	18	19	20	21			39	40					
31									9	10	11	12	13	14	15	16	17	18	19	20	21	22			40					
32										10	11	12	13	14	15	16	17	18	19	20	21	22	23							
33											11	12	13	14	15	16	17	18	19	20	21	22	23	24						
34												12	13	14	15	16	17	18	19	20	21	22	23	24	25					
35													13	14	15	16	17	18	19	20	21	22	23	24	25	26				
36														14	15	16	17	18	19	20	21	22	23	24	25	26	27			
37															15	16	17	18	19	20	21	22	23	24	25	26	27	28		
38																16	17	18	19	20	21	22	23	24	25	26	27	28	29	
39																	17	18	19	20	21	22	23	24	25	26	27	28	29	30
40																		18	19	20	21	22	23	24	25	26	27	28	29	30 31

(MOD)

3.2 Carrier-to-noise ratio

Section 3.3 of Annex 5 to Appendix **30 (S30)** provides guidance for planning and the basis for the evaluation of the carrier-to-noise ratios of the feeder-link and down-link Plans.

As guidance for planning, the reduction in quality in the down-link due to thermal noise in the feeder link is taken as equivalent to a degradation in the down-link carrier-to-noise ratio of approximately 0.5 dB not exceeded for 99% of the worst month.

For down-links, as indicated in Appendix **30 (S30)**, the World Broadcasting-Satellite Administrative Radio Conference, Geneva, 1977, adopted a *C/N* value of 14.5 dB for 99% of the worst month at the edge of the service area. The required feeder link *C/N* is 24 dB for 99% of the worst month, at the edge of the service area, to produce an overall *C/N* performance of 14 dB.

(MOD)

3.3 Protection ratios

For planning in Regions 1 and 3 at WARC ORB-88, the following protection ratios were applied for the purpose of calculating the feeder-link equivalent protection margins[1]:

– co-channel protection ratio = 40 dB;

– adjacent channel protection ratio = 21 dB.

The method for the calculation of the feeder-link equivalent protection margin is given in Section 1.7 of this Annex.

For revising the Regions 1 and 3 Plan at WRC-97, the corresponding values of aggregate protection ratio that were used to calculate the feeder link equivalent protection margins that appear in the alternative formula for overall equivalent protection margin given in Section 1.12 of this Annex, are specified in Recommendation ITU-R BO.1297 as follows:

– co-channel protection ratio = 30 dB

– adjacent channel protection ratio = 22 dB

[1] These protection ratio values may be used for the assignments notified, which are in conformity with this Appendix, brought into use, and for which the date of bringing into use has been confirmed to the Bureau before 27 October 1997.

However, it should be noted, that the revision by WRC-97 of the Regions 1 and 3 Plan, was in accordance with Recommendation 521 (WRC-95), based on "simultaneous planning of feeder link and downlink with calculation of overall equivalent protection margins" (as defined in Section 1.11 of Annex 5 to Appendix 30 (S30) and in Section 1.12 above) using the following values of aggregate protection ratio:

– co-channel 23 dB

– adjacent channel 15 dB

Recommendation 521 also specified that for the revision of the Regions 1 and 3 Plan no overall co-channel single entry C/I should be lower than 28 dB.

Nevertheless, for the assignments notified, which are in conformity with this Appendix, brought into use, and for which the date of bringing into use has been confirmed to the Bureau before 27 October 1997, the overall equivalent protection margins were calculated using a co-channel overall protection ratio of 30 dB and lower and upper overall adjacent channel protection ratios of 14 dB.

Revision of the Regions 1 and 3 Plan at WRC-97 was generally based on a set of reference parameters such as the average e.i.r.p., the reference earth station transmitting antenna, all test points placed within -3 dB contour, bandwidth 27 MHz and the predetermined value of C/N.

Protection masks and associated calculation methods for interference into broadcast-satellite systems involving digital emissions are given in Recommendation ITU-R BO.1293.

(MOD)

3.4 Feeder-link e.i.r.p.

The level of e.i.r.p. of each feeder link is specified in Article 9A of this Appendix.

The level of e.i.r.p. specified in the Plan can only be exceeded under certain conditions explained in Section 3.11 of this Annex (see also Article 5, paragraph 5.1.1 of this Appendix).

NOC

3.5 Transmitting antenna

(MOD)

3.5.1 Antenna diameter

The feeder-link Plan is based on an antenna diameter of 5 metres for the band 17.3 - 18.1 GHz and 6 metres for the band 14.5 - 14.8 GHz.

For all antenna diameters including antennas smaller than 5 metres for the 17.3 - 18.1 GHz band and 6 metres for the 14.5 - 14.8 GHz band, the off-axis e.i.r.p. shall not exceed the limits indicated by the curve A in Figure A of Section 3.5.3 of this Annex for the assignments notified, which are in conformity with this Appendix, brought into use, and for which the date of bringing into use has been confirmed to the Bureau before 27 October 1997 and by the curve A' of Figure A for other assignments.

NOC

3.5.2 On-axis gain

The on-axis gain for the 5-metre antenna at 17.3 - 18.1 GHz and for the 6-metre antenna at 14.5 to 14.8 GHz is taken as 57 dBi.

(MOD)

3.5.3 Off-axis e.i.r.p. of transmitting antennas

The co-polar and cross-polar off-axis e.i.r.p. values used for the original 1988 feeder-link Plan in Regions 1 and 3 are shown by curves A and B respectively in Figure A[1].

The corresponding off-axis e.i.r.p. values used for planning at WRC-97 are shown by curves A' and B' in Figure A as specified in Recommendation ITU-R BO.1295.

(MOD)

3.5.4 Pointing accuracy

The Plan has been developed to accommodate a loss in gain of 1 dB due to earth station antenna mis-pointing.

The deviation of the antenna beam from its nominal pointing direction must not exceed a limit of 0.1° in any direction. Moreover, the angular rotation of the receiving beam about its axis must not exceed a limit of $\pm 1^{\circ}$; the limit on rotation is not necessary for beams of circular cross section using circular polarization.

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[1] This antenna pattern is used for in the revision of the Regions 1 and 3 Plan for the assignments notified, which are in conformity with this Appendix, brought into use, and for which the date of bringing into use has been confirmed to the Bureau before 27 October 1997.

(MOD)

3.6 Transmitter power

The maximum transmitter power delivered to the input of the antenna of the feeder-link earth station per 27 MHz television channel shall be such as to ensure that the off-axis e.i.r.p. envelope in Section 3.5.3 is not exceeded except under certain conditions specified in Section 3.11 of this Annex.

NOC

3.7 Satellite receiving antenna

MOD

3.7.1 Cross-section of receiving antenna beam

Planning has generally been based on beams of elliptical or circular cross-section. When the assignments are implemented, or when the Plan is modified, administrations may use non-elliptical (shaped) beams as described in Annex 2 of this Appendix.

(MOD)

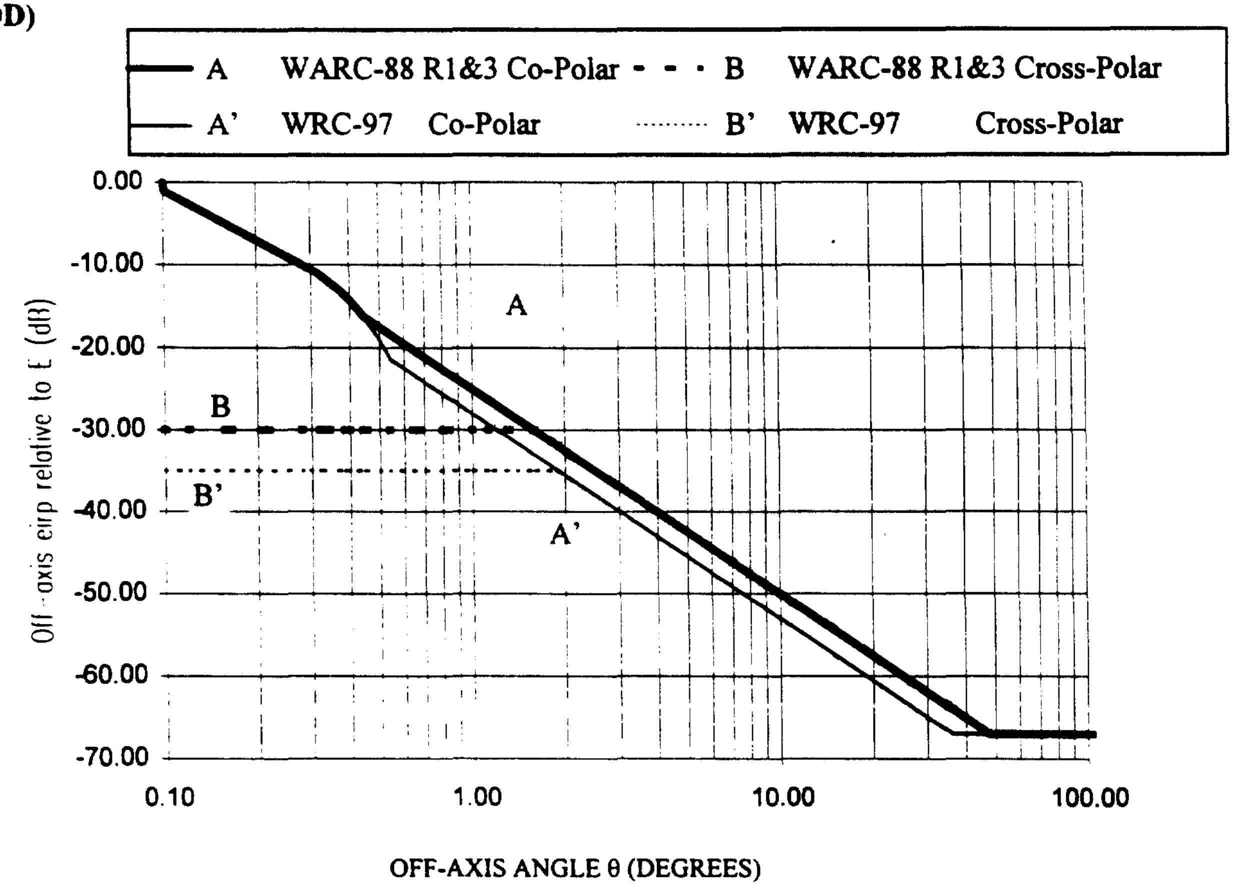

FIGURE A

Earth station e.i.r.p. at angles off antenna axis

Co-polar component in dBW:

Curve A (WARC-88)							Curve A' (WRC-97)						
E	for	0°	$\leq$	θ	$\leq$	0.1°	E	for	0°	$\leq$	θ	$\leq$	0.1°
E - 21 - 20 Log θ	for	0.1°	<	θ	$\leq$	0.32°	E - 21 - 20 Log θ	for	0.1°	<	θ	$\leq$	0.32°
E - 5.7 - 53.2 θ^2	for	0.32°	<	θ	$\leq$	0.44°	E - 5.7 - 53.2 θ^2	for	0.32°	<	θ	$\leq$	0.54°
E - 25 - 25 Log θ	for	0.44°	<	θ	$\leq$	48°	E - 28 - 25 Log θ	for	0.54°	<	θ	$\leq$	36.31°
E - 67	for	48°	<	θ			E - 67	for	36.31°	<	θ		

Cross-polar component in dBW:

Curve B (WARC-88)							Curve B' (WRC-97)						
E - 30	for	0°	$\leq$	θ	$\leq$	1.6°	E - 35	for	0°	$\leq$	θ	$\leq$	1.91
E - 25 - 25 Log θ	for	1.6°	<	θ	$\leq$	48°	E - 28 - 25 Log θ	for	1.91°	<	θ	$\leq$	36.31°
E - 67	for	48°	<	θ			E - 67	for	36.31°	<	θ		

where

E is the earth station e.i.r.p. on the antenna axis (dBW);

θ is the off-axis angle referred to the main lobe axis (degrees).

For planning purpose at WRC-97, an antenna diameter of 5 metres for the band 17.3 - 18.1 GHz and 6 metres for the band 14.5 - 14.8 GHz were assumed.

The on-axis gain for the 5 metres antenna at 17.3 - 18.1 GHz and for the 6 metres antenna at 14.5 to 14.8 GHz is taken as 57 dBi.

If the cross-section of the receiving antenna beam is elliptical, the effective beamwidth φ_0 is a function of the angle of rotation q between the plane containing the satellite and the major axis of the beam cross-section and the plane in which the beamwidth is required.

The relationship between the maximum gain of an antenna and the half-power beamwidth can be derived from the expression:

$$G_m = 27\,843/ab$$

where:

a and b are the angles (in degrees) subtended at the satellite by the major and minor axes of the elliptical cross-section of the beam. An antenna efficiency of 55% is assumed.